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THE MONTREAL SPRING MEETING OF THE A.A.V.S.O., MAY 31–JUNE 2, 1957

By Clinton B. Ford*

In May 1940 the American Association of Variable Star Observers was invited to its first meeting ever held in Canada. Members who recalled that excellent meeting, held in Toronto with the University of Toronto and the Toronto Centre of the Royal Astronomical Society of Canada as hosts, looked forward with special interest to the 1957 spring meeting of the Association, to be held in Montreal at the kind invitation of the Sir George Williams College and the Montreal Centre of the R.A.S.C. Our Canadian friends, led this time by Mr. Charles M. Good, President of the Montreal Centre, again left no stone unturned to treat us royally and to organize every detail perfectly.

Following an official welcoming by Mr. Good, and by Mr. E. Russell Paterson on behalf of Sir George Williams College, the Friday evening address on May 31 was given by Dr. John S. Marshall of the Stormy Weather Group, McGill University, entitled "Storm Studies by Radar". Included were many interesting moving pictures of cloud formations as detected on radar screens. A guided tour of the newly-opened College buildings preceded the serving of refreshments in the Common Room of the College. Delicious French *gateaux* and a special cake decorated with "A.A.V.S.O." testified to the magnificent job done by the Centre's refreshments committee, headed by Mrs. Yane.

The Saturday morning business meetings were called to order at 9:45 a.m. at Sir George Williams College, with A.A.V.S.O. President Richard W. Hamilton in the chair. Following the Treasurer's Report, which showed continued improvement in the financial status of the Association, Dr. Peter M. Millman of the National Research Council in Ottawa described the I.G.Y. meteor observing programme, and distributed copies of the official I.G.Y. calendar. The reading of committee

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reports, including an interim report by Mrs. Margaret W. Mayall, Director of the A.A.V.S.O., left time for the presentation of nine papers before the noon recess. These included several by the Observing Group of the New York City A.A.S., and some excellent photographs of Comet Arend-Roland by Mr. Cuevas of that group.

Papers continued Saturday afternoon, with Mr. Walter P. Reeves, Vice-President of the A.A.V.S.O., in the chair. A total of 17 papers were presented at the meeting, covering a wide variety of astronomical topics. Papers are summarized in "A.A.V.S.O. Abstracts", to be distributed by the Headquarters of the A.A.V.S.O.

The Saturday evening dinner was held at the Laurentian Hotel, the menu being characteristically French. There was only one stumbling block, "Sirop d'Erable". This was finally clarified by Mr. Good as "just Johnny cake and maple syrup". Speakers at the dinner included M. Jean Asselin, President of the Centre Français de Montréal of the R.A.S.C. (a *raconteur par excellence*), and Dr. Millman, who showed a fine series of pictures of his recent trip to the Canadian Arctic.

The Sunday feature of this A.A.V.S.O. meeting was a very special one. Members and guests assembled at the Montreal Airport for an interesting visit to the airport's control tower and the Dominion Weather Bureau Station, and were allowed inside "No Admittance" doors to witness the detailed operations of both. As many as could be accommodated were then treated to a 40-minute airplane flight in a Viscount over the St. Lawrence Seaway Project, compliments of Trans-Canada Airlines. Arrangements for this special feature were in the capable hands of Mr. W. A. Warren of the Montreal Centre, who gave preference generously to "non-residents". Needless to say, much camera film was expended, and the flight was an exciting and unforgettable experience.

Following luncheon at the "Miss Montreal" restaurant near the airport, members, guests and hosts gradually disbanded. From the *gateaux* to the Viscount flight, and from the radar screens to R Herculis and the optimistic Treasurer's Report, this was surely one of the finest A.A.V.S.O. meetings ever held. Our generous hosts have set an example that will be hard to match when they next visit us in "the States".

John R. Collins

John R. Collins, who had the longest term of membership of any member in the Society, died on September 19, 1957, at the age of 92. An obituary will appear in the next number of the Journal.

Correction

The date of the photograph of Comet Arend-Roland, shown on page 247 of the August issue of this Journal, should read April 30 (instead of April 13).

COMET MRKOS, 1957d

It is not often that the opportunity arises for the observation of two naked-eye comets within a few months; but such has been the case this year. In the following pages we have reports from Canadian observers on their observations of the recent appearance of Comet Mrkos.—Editors.

OBSERVATIONS OF COMET MRKOS IN NORTHERN ALBERTA

By Ian Halliday

The sudden appearance of Comet Mrkos as a naked-eye comet near the beginning of August provided another excellent opportunity for comet observers less than four months after the excitement of Comet Arend-Roland. Because of its position in the sky, especially during the first week of August, Comet Mrkos was most easily observed in mid-northern latitudes.

On the night of August 4/5, about 2.30 a.m., the writer noticed the comet low in the north while driving between Calgary and Edmonton en route to the Newbrook and Meanook Meteor Observatories. The comet was soon lost in a dense ground fog but was observed and photographed the following night from Newbrook by Mr. A. A. Griffin and the writer. Although it was later found that the comet had been discovered about three days earlier by Mrkos in Europe no knowledge of this reached the writer for some days after the first photographs were taken. Comet Mrkos had many independent discoverers since it first appeared in an observable position near maximum brightness, shortly after perihelion passage.

During the next three weeks a series of photographs was secured at Newbrook and Meanook. Figure 1 shows a photograph on the night of August 7/8 by Mr. J. M. Grant and Mr. V. N. Beck at Meanook. The comet was then near lower transit. The picture was taken with a K 19 aerial camera, focal length 12 inches, focal ratio f/2.5, exposure time 5 seconds. The camera is normally used with a diffraction grating as a meteor spectrograph but the grating was removed for comet photographs. Note the auroral rayed arc above the comet and the All-Sky Auroral Camera mounted on the foreground rooftop, silhouetted against the sky. The bowl of the Big Dipper is seen in the upper left corner.

During early August the comet's motion was eastward among the stars, gradually changing to south-east later in the month. As seen in the north, near lower transit, the comet's position at midnight was first slightly east of north and later in the month considerably west of north. At Meanook

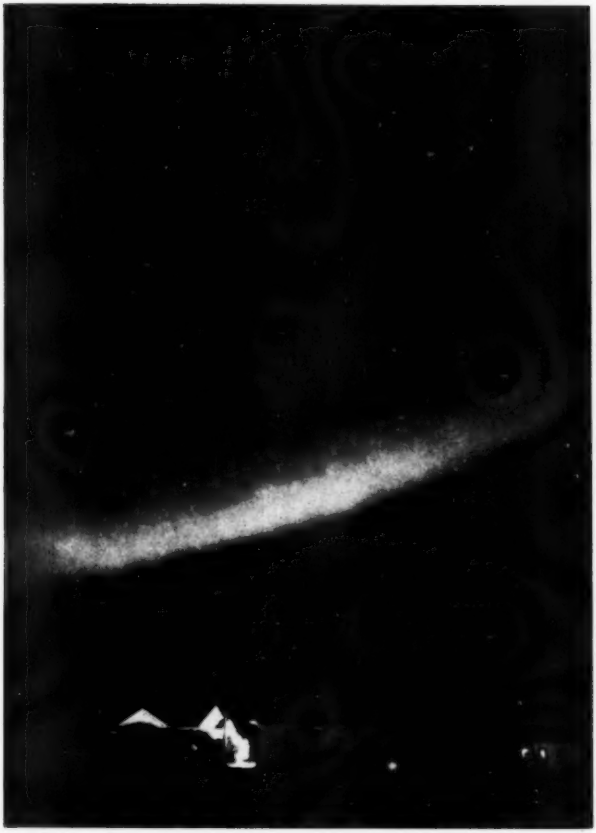

FIG. 1—Comet Mrkos and aurora photographed at Meanook, Alberta, August 7, 1957, $22^h\ 55^m$ M.S.T.

and Newbrook (latitude 54°) the comet was circumpolar during the first half of August and could be seen all night, with the head sometimes within 2° of the horizon and the tail rising nearly straight up.

The photographs in figure 2 show the rapid motion of the comet among the stars. Figure 2a was taken at Newbrook on August 5/6 with a Wray f/0.71 lens, 2½-inch focal length, exposure about one second. The comet is seen near the northern horizon behind the radio tower which is used for inter-station communication when the Super-Schmidt meteor

a Aug.6, 2^h 05^m

bAug. 14, 22^h 03^m

c Aug.16, 21^h 56^m

d Aug.22, 22^h 26^m

FIG. 2—Four photographs of Comet Mrkos showing motion among stars. All times are Mountain Standard.

cameras are in operation. Another auroral display may be seen at the top of the picture. The two stars just above the tower are the two bright ones above the all-sky camera in figure 1. The comet has moved about five degrees in the two-day interval.

Figures 2b, 2c, 2d, show later positions photographed at Meanook. Note the structure of the comet tail in photograph 2b. This was a 30-second exposure and shows appreciable trailing of the stars (and comet) since the camera was not guided. Three of the stars are designated by letters from A to C to show the motion of the comet. The total motion from figure 2a to 2d is about 50° in 17 days. The comet was fading quickly by the time of the last picture.

Dominion Observatory,
Ottawa.

OBSERVATIONS AT THE DAVID DUNLAP OBSERVATORY

A NUMBER of independent observers discovered this comet. The earliest communication to reach the Bureau of the International Astronomical Union in Copenhagen was that of Antonin Mrkos of the high-altitude observatory of the High Tatras, Czechoslovakia. His first observation was made on August 2, 1957. The comet was named after this discoverer, although apparently it was observed as early as July 29 in Japan. The brightness of the comet changed rapidly from mag. 3 at the time of discovery to mag. 1 on August 4.

Because of unfavourable weather the comet was not seen at the David Dunlap Observatory until August 11, but after that it was photographed with both the 19-inch reflector and the Zeiss wide-angle camera. Thirteen plates on eight different nights were obtained.

The appearance of the comet was marked by a very bright, star-like nucleus and a tail extending about ten degrees from the head. Actually two tails were observed, one relatively straight and the other fan-shaped and strongly curved. The latter tail showed a streamer-like structure characteristic of some aurorae. On the last plate of this series, taken on August 27, the curved tail had shortened to some four degrees and had lost its structure, while the straight tail remained unchanged and still was fairly bright.

The figure shows a photograph taken with the 19-inch reflector on August 17, exposure time two minutes on Eastman 103-a-0 emulsion. The tail extends just over one degree and shows the streamer-like structure. The splitting of the tail which was present at this time does not show on this plate for it was more distant from the nucleus. G. A. B.

SOCIETY MEETINGS

During the summer months of each year meetings of learned societies are held which provide an opportunity for scholars to report the results of their investigations and to keep abreast of the rapid development of contemporary science. We are printing informal reports on a few of this summer's meetings in the following pages.—Editors.

THE AMERICAN ASTRONOMICAL SOCIETY'S NINETY-EIGHTH MEETING

The American Astronomical Society meets twice or three times a year. The meeting extends over three days and regularly includes sessions for papers, a conference on a particular topic and a public lecture. The ninety-eighth meeting was held from August 18 to 21, 1957 at the University of Illinois in Urbana. Over a hundred astronomers were in attendance and about forty papers were presented; the conference was on the subject of "Radio Sources Outside our Galaxy", and the public lecture was delivered by Dr. Otto Struve on "The Double Star, Sheliak".

In a brief account it is possible only to single out a few of the papers which appealed to the writer as particularly interesting or timely. One such paper was by Sidney van den Bergh of Perkins Observatory on "Interstellar Gas and Star Creation". He pointed out that recent observations of radio astronomy show that our galaxy and the Andromeda galaxy contain "surprisingly little" interstellar gas; whereas we used to believe that the mass of the disk of our galaxy was about half in the form of gas and dust and half in the form of stars, the more recent view is that the ratio is about one to seven. Calculations involving the rate of formation of new stars from the gas show that the gas in the solar vicinity would be exhausted in about 700 million years, even if we make allowance for the ejection of matter from evolving stars. Also calculations show that in the centre of the galaxy there is a great deficiency of gas compared with what might be expected to have been ejected in five billion years from the stars evolving there. The author presented as an explanation the idea that the spiral arms of the galaxy (where we live) are continually being rejuvenated by an outward flow of gas from the central parts.

K. Aa. Strand of the Dearborn Observatory, in a paper entitled "The Expansion Age of the Orion Nebula Cluster", presented strong evidence

that the cluster of stars near the Trapezium in Orion is not older than 300,000 years. If this is true, then these stars are the youngest stars discovered so far. The idea of such extreme youth came as something of a shock to the astronomers present. One of them asked if, in such a youthful cluster, one could not expect to locate stars in the very process of being formed. Dr. W. W. Morgan of the Yerkes Observatory, who has also studied this region, ventured a cautious opinion that there may indeed be some star-like fragments of nebulosity which could be so described.

There was a series of papers by different authors on various aspects of the forthcoming artificial satellite. Some dealt in mathematical detail with the methods of computing the orbit, and others dealt with the visibility of the satellite. Both Armand Spitz of the Spitz Laboratories and Raymond H. Wilson Jr. of the Naval Research Laboratory discussed the advantage of having a faceted reflecting surface on the satellite rather than a spherical surface. It appears that plane mirror surfaces would increase the brightness from fifth or sixth magnitude to second or third, but the satellite would exhibit only flashes of this brightness as it turned in the sunlight.

There were several papers on the subject of Comet Arend-Roland. In one of these William Liller of the University of Michigan Observatory demonstrated that the light of the comet's tail could be explained by particles of diameter one twenty-thousandth of an inch separated from one another by a distance of 50 yards.

Gerard P. Kuiper of the Yerkes and McDonald Observatories described recent infra-red observations of the planets and satellites. His observations have led him to the conclusion that the cloud cover of Venus is very probably composed of polymerized carbon suboxide, C_3O_2; definitely, he said, it is not composed of water droplets.

Papers presented by Canadian astronomers were "The Statistical Equilibrium of a Hydrogen Nebula" by Leonard Searle, and "A Spectrographic and Photometric Investigation of Visual Binaries" by G. A. Bakos and J. B. Oke, all of the David Dunlap Observatory.

A highlight of the conference on "Radio Sources Outside our Galaxy" was a frank discussion by J. L. Pawsey of Australia and A. Hewish of Cambridge of the serious discrepancies which exist between the Australian and the Cambridge lists of radio sources. R. Minkowski discussed "The Problem of Identification of Extra-galactic Radio Sources" and painted a rather pessimistic picture of the likelihood of making identifications beyond the few close galaxies and the colliding galaxies which have already been identified as radio sources. G. C. McVittie of the University of Illinois presented results of calculations of a cosmo-

logical nature in a paper entitled "Model Universes Derived from Counts of Very Distant Radio Sources".

In the Russell Lecture on the subject of "The Problem of the Double Star, Sheliak (β Lyrae)", Otto Struve of the Leuschner Observatory reviewed the investigations of himself and others on this remarkable "contact" binary star. He presented evidence that this system is slowing down, and pointed out that, although the change in period is barely detectable over the interval of observation, the rate is extremely rapid on the cosmic time scale. If other evolving binary stars go through this rapid phase of lengthening period caused by loss of mass, then the cosmological importance of the regeneration of so much interstellar gas is very great indeed.

J. F. H.

"URSI"

The twelfth General Assembly of the Union Radio Scientifique International, or International Scientific Radio Union, was held in Boulder, Colorado, from August 22 to September 5, 1957. The Union is concerned with all branches of radio as a scientific tool, and among them the still burgeoning science of radio astronomy. There were almost 900 delegates and visitors, many with their families. They included representatives of all the major centres of research in radio astronomy throughout the world, and a number from Canada.

The meetings were held on the campus of the University of Colorado, in a beautiful setting at the base of the Rocky Mountains. Our hosts, the Boulder Laboratories of the National Bureau of Standards and the High Altitude Observatory of the University, had arranged a glorious display of the American West for their visitors.

The technical sessions covered the full range of topics connected with radio astronomy and in addition meetings were held jointly with other Commissions of the Union. There was a general session devoted to the International Geophysical Year. Perhaps, if the item of greatest general interest had to be selected, one would choose the announcement that voice signals had been transmitted and reflected back from the moon. We heard a tape recording of such a transmission made at the Naval Research Laboratory on August 22, 1954, in which the words "Hello testing . . . one two . . . three four . . . etc." were each repeated by the moon after about a two-and-a-half-second delay. Other items, among many, were the announcement of a careful series of measurements by Mayer which showed that the Crab Nebula emits polarized radiation at radio wave-lengths as it does in the optical region, and that the 250-foot

telescope at Jodrell Bank had been put into operation and was performing satisfactorily.

The meetings at Boulder provided a stimulating survey of radio astronomy and a valuable opportunity for personal contact among widespread workers in this rapidly growing field.

D. A. M. R.

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

A SYMPOSIUM on Aeronomy (physics of the upper atmosphere) was presented as part of the general I.U.G.G. Assembly at Toronto, September 3–14, 1957. Of particular interest to earthbound astronomers are the studies made with rockets by groups such as the Naval Research Laboratories in the United States, which sent a large delegation to the symposium. Some of their results are mentioned below.

Atmospheric pressure, density, and temperature were known accurately up to a height of 30 km. before the advent of rocket research. One of the major goals of the rocket scientists is to extend our knowledge of these quantities to the greatest heights that can be reached. Data are now available for heights up to 220 km. at White Sands, New Mexico, although above 100 km. serious discrepancies exist between the values obtained by different methods. For example, T. A. Chubb described a method of determining atmospheric densities by measuring the absorption of solar X-rays in the 8 to 100 A. region. Between 100 and 130 km. the densities measured in this way are a factor of three smaller than those obtained from earlier flights in which mechanical or electrical pressure gauges were used as detectors. To investigate the geographical variation in the upper atmospheric density, balloon-launched rockets (Rockoons) have been released from ships in Arctic waters and have carried pressure gauges up to 75 km. H. E. LaGow finds that although the density of the Arctic upper atmosphere agrees with the White Sands density up to this altitude, the pressure and temperature at the 40 km. level are higher in the Arctic.

C. Y. Johnson presented results obtained with a R.F. mass spectrometer capable of scanning from 6 to 56 atomic mass units once per second during a rocket flight. This sensitive method of detecting atomic and molecular ions in this mass range will help to establish how the chemical composition at high levels varies from that at sea level.

H. Friedman summarized the N.R.L. results on the solar spectrum in the X-ray (1 to 100 A.) and extreme ultra-violet regions as measured with photon counters to a height of 130 km. It is interesting that the

intensity of the hard X-rays shows a consistent correlation with variations in the intensities of the visible coronal lines.

Over a seven-year period the intensity of solar Lyman alpha ($L\alpha$) radiation has varied widely but in accordance with the known changes in solar activity. Absorption of $L\alpha$ is believed to be the chief factor controlling the D-layer ionization. Enhancement of $L\alpha$ and hard X-ray emission during a solar flare is being measured with Rockoons launched from ships. Several successful flights have shown that during a flare radiation at 3 and 4 A. penetrates well into the D-layer (about 80 km.), whereas for a quiet sun these wave-lengths are not observed below 100 km.

H. E. Newell presented a detailed account of the preparation of artificial satellites to be launched during the I.G.Y. These satellites will be spheres with a diameter of 20 inches, weighing about 21 pounds, and will be launched by means of a three-staged rocket weighing 11 tons. Valuable experiments that can be performed from such a small satellite include observations of solar X-rays and ultra-violet radiation, cosmic rays, the earth's magnetic field, the radiation imbalance of the atmosphere, numbers of micrometeorites, detection of auroral particles, the density of the upper atmosphere, cloud cover above the earth, and geodetic parameters. The instrumentation of the satellites for several of these experiments is nearly complete but the major problem still is to raise the satellite high enough above the earth and to deflect it into the proper orbit. A motion picture was presented to illustrate the actual manufacture of the satellite shells and of the various detectors and miniature telemetering circuits that will be mounted in them.

V. G.

Two subjects, among others, were of special interest at the sessions of the International Association of Geodesy. The first of these was related to the great system of positions determined in Canada during the past ten years by J. R. Ross, by the use of the radar technique called Shoran. The yardstick for this method is the velocity of propagation of radio waves; and it was therefore very important to have precise values for this quantity. Fortunately, it developed that during the past three years, since the last meeting of the Association there has been a series of measurements which agree remarkably well with one another, including measurements by means of the geodimeter (pulsed light of optical frequencies), the tellurometer (ten-centimetre radio waves) and a microwave interferometer. From the geodesist's point of view, one of the

happiest aspects of this work was the fact that the extreme care which had been put into the measurements of the British bases at Caithness and Ridge Way turned out to be, not unnecessary fiddling, but an essential element in the determination of this most important of all constants. From the Ridge Way base, R.C.A. Edge of the Ordnance Survey reported a determination of 299,792.4 ± 0.11 km./sec., the finally adopted value being 0.1 km./sec. higher.

The second subject, which formed a principal part of a great many discussions in one way or another, was the geoid. This is an imaginary surface which continues the mean sea level under the continents. J. F. Hayford once remarked that if narrow canals were cut through the land everywhere, then the geoid represents the level of the water in these canals. If a surveyor says that you are 354 feet above mean sea level, then this means, within a foot or so, that the geoid is 354 feet below you.

Geodesists have used the geoid as an essential tool of thought in almost all portions of their field. Heights have been considered as measured from it; horizontal angles have been considered as angles between lines on the geoid; bases are reduced to the geoid after measurement; gravity and astronomical data are considered to define its shape.

In this meeting, the concept of the geoid was continuously under attack. The most successful attack on it was led by the section on levelling. This section managed to re-define the concept of height in such a way as to eliminate reference to the geoid. In place of vertical distances above the geoid, scientifically measured heights will hereafter refer to equipotential surfaces, each one denoted by a number called the geopotential number. The geopotential number will be roughly the same as the old heights; but what it will do exactly is to ensure that water will never flow from a point of lower geopotential number to one of higher number. With the old heights, water might sometimes flow uphill, numerically at least. This is because the equipotential surfaces are further apart in some places than in others, so that points having the same number of metres above sea level would not be on the same equipotential surface. Since the separations of the geopotential surfaces are a fraction of one per cent. greater at the equator than at the poles, the geopotential numbers are taken equal to the separation of the surfaces at 45°.

In the triangulation section, the attack on the geoid was led by Martin Hotine, of the British Colonial Surveys Office. Hotine raised the question, through a study group, why we must always give angles on the geoid and must reduce our lengths to the geoid. Hotine prepared an elegant exposition in tensor form of his point of view, supported by computations by his assistant, H. H. Brazier. The computations showed that triangula-

tion can be computed, like photogrammetry, in three dimensions, without any reference to the geoid. The advisability of so doing was attacked by J. A. O'Keefe, of the Army Map Service in Washington, who felt that in a long chain the errors of the determination of the vertical by means of rays would accumulate, and that the classical assumption that the angles are effectively on the surface of the geoid would work better in the long run. It was agreed that further test computations are needed. A. A. Izotov, of the U.S.S.R., drew attention to the fact that although most geodesists regard their angles and bases as being on the geoid, they calculate with them using tables based on a regular ellipsoid of revolution. For example, in the general adjustment of Western Europe, it was assumed that the form of the geoid was that obtained by revolving an ellipse around its short axis. The long axis of the ellipse was taken as $a = 6{,}378{,}388$ International metres and the shorter or polar axis was assumed to be shorter by 1/297 of this amount. Izotov drew attention to the fact that in the U.S.S.R. the height of the geoid above the ellipsoid is carefully determined, and this is made the basis for the reduction of the bases, not to the geoid, but to the ellipsoid. He remarked that from the theoretical point of view, the triangulation was not even consistent unless the bases were reduced to the ellipsoid.

On this point, Antonio Marussi, of the University of Trieste, Italy, remarked that it would be possible to establish a consistent system for calculating triangles directly on the geoid by modifying the ellipsoidal elements slightly. O'Keefe remarked that within terms of the order of 1 to 10 million, Marussi's suggestion was equivalent to projecting on to a wrinkled ellipsoid.

In the geoid section, Mrs. Irene Fischer of the Army Map Service in Washington produced evidence that the Hough spheroid, with an equatorial diameter of 6,378,270, is correct within a few tens of metres.

In the same section, W. Markowitz, of the U.S. Naval Observatory, pointed out that the observations of position from the moon and the artificial satellite will lead to true geocentric positions, expressible in ordinary Cartesian co-ordinates from the centre of gravity of the earth, and bearing no relation to the geoid.

In the section on gravimetry, the old system of reducing gravimetric data to the geoid was abandoned in favour of a system in which the gravity anomaly, or difference between prediction and observation is found at the actual height of observation.

All in all, it was a bad session for the geoid, that tough and flexible notion which has served so well in the past.

THE UPPER ATMOSPHERE AND CURRENT RESEARCH

By Peter M. Millman

During August and September of 1957 I was privileged to attend two important international scientific congresses. These were the XII General Assembly of the International Scientific Radio Union (U.R.S.I.), which was held from Aug. 22 to Sept. 5 at Boulder, Colorado; and the XI General Assembly of the International Union of Geodesy and Geophysics, meeting from Sept. 3 to Sept. 14 in Toronto, Ontario.

Discussions in one particular field of research played a major part at both conferences. This field was the atmosphere of our earth, and in particular research on the upper atmosphere, that region lying well above the general area of clouds and surface weather. The spotlight of world scientific attention has recently turned in this direction because of the current importance of certain radio problems, and because of the widespread interest in such projects as long range missiles and artificial earth satellites.

Since the final publication of scientific papers is often delayed for some months or even years, it may be of interest to review here some of the highlights of these meetings. First, however, I would like to pay tribute to the intensive planning and preparation for the sessions, carried out by the local committees at both Boulder and Toronto. The delegates, and their families, were royally entertained, and the excellent accommodations provided for the business of the assemblies were only matched by the recreational "divertissements" organized over week-ends and on free evenings. To Mr. K. A. Norton, Mr. A. H. Shapley and their committee at Boulder, and to Prof. J. T. Wilson and his committee at Toronto, I would like to say a hearty "thank you" on behalf of all those who enjoyed their hospitality.

One of the most valuable features of international scientific assemblies is the opportunity of meeting personally the scientists from other parts of the world, and of discussing with them problems of mutual interest. At Boulder there were nineteen Canadian delegates. The largest delegation from outside the U.S.A. was that from Japan. It numbered 25 delegates and it was a distinct pleasure to me to meet so many from a country that I called home for many years. I had the opportunity to practise again my conversational Japanese.

In Toronto we from North America worked with the delegates from the U.S.S.R. in mapping out the international co-operation for the I.G.Y. In particular we discussed the plans for the interchange of information about the aurora. There was a most happy spirit of good will and co-

operation among all those attending these discussions and I thought what a pity it is that we cannot get together like this more frequently. The world-wide fellowship in fundamental science is one of mankind's most precious heritages in this modern age of international political tensions.

In listening to the papers presented at these meetings it was evident that advanced experimental techniques are now providing the quantitative answers to many problems for which only very rough qualitative data were available in the past. Of prime importance among these new techniques are the upper atmosphere rockets and improved radio methods of research. Some of the more interesting and significant portions of this new knowledge about the upper atmosphere are summarized below without any attempt to cover completely the many papers read.

Whistlers

Whistlers are radio signals which occur in the audio-frequency range, in general between 1 and 15 kilocycles. The normal whistler starts at a high pitch and this pitch drops with time. It is now generally agreed that the explanation suggested by L. R. O. Storey of Ottawa, Ont., is correct, namely that whistlers originate in the electrical discharge associated with a lightning flash, and that they are propagated along the magnetic lines of force of the earth's field. They travel from one hemisphere to the other along paths that may be well over 1,000,000 km. in length. M. G. Morgan from Hanover, N.H., reported that using two bases, one in the Aleutians and one in New Zealand, successful correlation between individual lightning flashes and the received whistler signals had been achieved

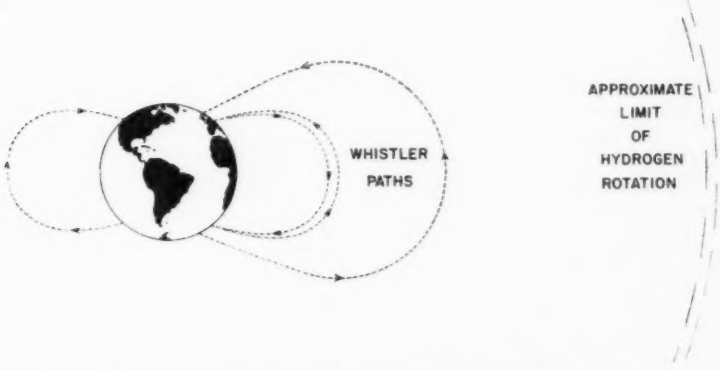

FIG. 1— Illustration of typical whistler paths. The concept of the limit of the rotating gas was presented by L. R. O. Storey at the XI General Assembly of I.U.G.G.

in May 1957. Multiple whistlers are produced by the same signal bouncing back and forth a number of times from hemisphere to hemisphere. R. Gallet of Boulder, Colo., referred to a whistler which had been followed over a 1,050,000 km. path 42 times. The importance of whistlers in atmospheric research is that they make possible studies of the extreme outer atmosphere, or exosphere. Using whistler data Storey has estimated that the earth's magnetic field may hold the hydrogen gas so that it rotates with the earth out to a distance of 8 earth-radii, or approximately 50,000 km. Outside this there is a slip layer a few kilometres thick and then the interplanetary medium which does not rotate. This gives us the concept of an atmosphere of much greater extent than had previously been considered.

Ozone

H.-K. Paetzold of Weissenau, Germany, described studies of the height of the ozone layer made with a special interference filter carried on balloon flights in south Germany at 47° N. latitude. The primary maximum of the ozone layer was always found between 20 and 28 km. height. The contour of this maximum could be either sharp or broad. In spring and summer a secondary maximum was generally found between 10 and 16 km. More rarely a third maximum was suspected between 1 and 5 km. It was concluded that there are breaks in the circulation pattern near heights of 10 and 22 km.

The Airglow

The term airglow is used to refer to the night-sky luminescence which is not directly associated with active auroral displays, but appears more or less continuously in the earth's atmosphere. Studies of the airglow intensity by F. E. Roach of Boulder, Colo., show hourly changes in the distribution pattern of this phenomenon with a characteristic pattern dimension of about 1200 km. Maximum intensities of the airglow in the United States seem to occur near 38° N. geographic latitude (45° N. geomagnetic latitude).

R. Tousey from Washington, D.C., reported on the height of the airglow emission of the oxygen green line at 5577 A. and the sodium *D* lines at 5893 A. as measured on four rocket flights made at White Sands in the period 1955 to 1957. The maximum of the emission of these lines lies between elevations of 90 and 100 km. with a lower border of emission near 85 km. and an upper border near 110 km. The *D* lines are emitted at slightly lower elevations than the green line. These values agree with estimates of height made by various indirect methods. Most of the other

emissions of the airglow originate in the same height range with the exception of OH, which starts at 50 km. height, and the red oxygen lines at 6300 A. and 6363 A., which seem to be produced above 160 km.

A. V. Jones from Saskatoon has found the *H* and *K* lines of ionized calcium emitted in the twilight sky at heights near the 100 km. level, and sometimes as high as 150 km. For the last three years these lines have shown a maximum intensity in August as well as other smaller maxima earlier in the year. Calcium intensity shows no correlation with the occurrence of aurora; a possible connection with the strong Perseid meteor shower in August was suggested.

Auroral Temperatures

From a study of high dispersion spectra of the nitrogen bands in the aurora D. M. Hunten of Saskatoon has measured auroral temperatures which seem in good agreement with those determined on rocket flights. He finds values ranging from 150° K. at the extreme lower borders of some rays up to 465° K. for the high red aurora. To explain some records it must be assumed that auroral temperatures ranging from 200° to 400° K. are included in a single photograph. A positive temperature gradient of about 6° per km. of height is indicated.

Auroral Cameras

A. I. Lebedinsky from Moscow described the all-sky camera which has been designed and built in the U.S.S.R. for the International Geophysical Year auroral observations. This has a primary convex spherical mirror 400 mm. in diameter and a concave secondary mirror figured to reduce the aberrations near the edge of the field which is 180° across. Both mirrors reflect from the front surface and the aluminum coat is covered with a hard film which greatly increases the lifetime of the mirror coating. The cameras are designed to take 35 mm. film and exposures of 20, 10 or 5 seconds can be given. Forty of these cameras will be in use during the I.G.Y.

Ionospheric Fine Structure

J. C. Seddon from Washington, D.C., gave the daytime electron distribution in the ionosphere as determined from rocket flights. Receptions of CW (continuous wave) from the rocket at two frequencies, 7.75 and 46.5 mc./sec. were compared. It was found that the base of the E region was very regular and near 90 km. elevation. Rapid increase in ionization near 86 km. corresponded to sporadic E conditions, while during the blackout on July 4, 1957, the curve of electron density started to increase at 55 km., showing excess ionization at low levels.

W. H. Pfister of Cambridge, Mass., also mentioned the determination of electron density on rocket flights. Several flights gave an indication of successive peaks in the electron density separated by height differences which averaged 5 km. and covered the range from 90 to 120 km.

Additional evidence of this fine structure in the ionosphere was presented by C. D. Ellyett from New Zealand, reporting on results obtained by the team working at Christchurch. Using a pulsed, 1.75 mc./sec. equipment beamed vertically a reflecting layer at 85 km. height was found to be continuously present, while additional layers near 95 km. and 105 km. were more variable in their behaviour. Lower layers near 76 km., 70 km. and 64 km. appeared irregularly, particularly in the daytime, and a low daytime layer at 54 km. has been recorded. This last corresponds to the increase in electron density at 55 km. found on rocket flights, and noted above.

D. K. Bailey from Washington, D.C., reported on a study of forward scatter over paths varying from 800 to 2100 km. in length, on a frequency of 50 mc./sec. During the day the scattering level was at 70 km. height. A scattering level at 85 or 86 km. was found throughout the 24 hours, but particularly at night, while some scattering as high as 104 km. occurred.

The above results give us a fairly consistent picture of the layered structure of the ionosphere.

Winds

A general picture of the winds in the 75 to 105 km. height range was presented by L. G. H. Huxley from Adelaide, reporting on the work of the Australian team which includes A. A. Weiss, W. G. Elford and others. Winds were determined from a study of the Doppler shift of the ionized columns left by meteors, as recorded with CW, 27 mc./sec., equipment, supplemented with pulsed radar. Characteristic mean winds for each hour of the day were determined for periods of one or two weeks by combining all usable echoes in the period. Wind motion was found to be predominently horizontal, any vertical motion being so small as to be non-significant. Three components of wind were described: (a) a steady zonal wind with the prevailing component towards the east at about 50 metres/sec.; (b) a diurnal component with the wind vector rotating generally counter-clockwise every 24 hours, mean speed about 30 metres/sec.; (c) a semi-diurnal component with the wind vector rotating counter-clockwise in a 12-hour period and a mean speed somewhat less than that of the diurnal component. The prevailing components of the winds for various seasons form a natural extension to those found at lower levels using balloons and rockets.

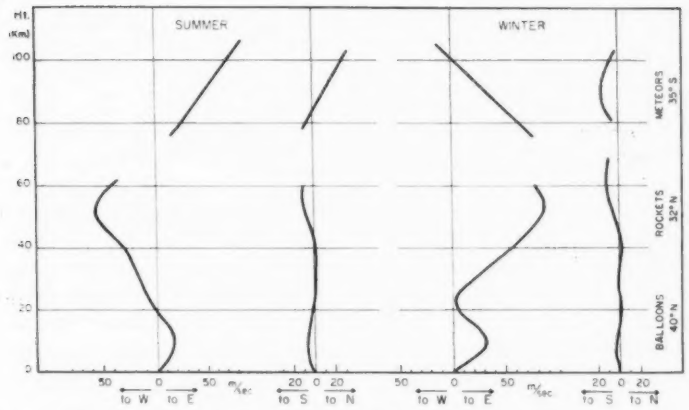

FIG. 2—The relation between the prevailing wind components of the upper atmosphere determined by different methods, as presented by L. G. H. Huxley at the XII General Assembly of U.R.S.I.

Meteor Ionization

Additional measures of the height of long enduring meteor echoes by D. W. R. McKinley and P. M. Millman at Ottawa have confirmed a height range extending from a mean of 88 km. for slow meteors to 100 km. or higher for the faster meteors. Echoes recorded during the Perseid shower in August show a diurnal height variation from 92 km. at 2100 hrs. local time to a maximum of 103 km. at 0100 hrs. and down to 94 km. at 1100 hrs.

L. A. Manning at Stanford, Calif., has found that a model of stratified horizontal winds will explain certain features of over-dense meteor ionization trails. A mean vertical wind gradient between 90 and 100 metres/sec. per km. height difference is indicated, and a similar value results from a statistical study of fading frequency. The characteristic dimension of the primary stratification is between 6 and 7 km., a figure in very good agreement with other determinations of fine structure near the 100 km. height level.

V. R. Eshleman, also from Stanford, Calif., is using an array of 96 yagi aerials arranged in two rows 2000 ft. long. These work at a frequency of 23 mc./sec., with a pulse length of 100 micro-seconds and peak power of 90 kw. It is estimated that meteors are recorded down to the 15th magnitude with this equipment. Hourly echo rates up to 6000 are observed at the diurnal maximum between 0300 and 0600 hrs. local time.

A mean diurnal range in echo rate of 50:1 is found. Preliminary estimates indicate that for these faint meteors the increase in numbers is by a factor of 2.5 for each fainter magnitude.

Meteor Velocities

No hyperbolic meteor velocities are found by Eshleman down to the 13th magnitude. This is confirmed by A. C. B. Lovell's report of the work of J. G. Davies at Manchester, England. In thousands of orbits, determined there from radio observations of meteors ranging from 7th to 10th magnitude, no hyperbolic velocities have been found. A large majority of these faint meteors seem to have orbits with periods of 1.5 to 2.0 years.

Hence we still have no single example of an instrumentally recorded meteoric body which can without any element of doubt be classified as interstellar. The evidence is overwhelming that meteors, as a class, are part of the sun's family.

CANADIAN SCIENTISTS REPORT

VIII. GEODETIC SURVEYS IN CANADA

J. E. R. Ross

Dominion Geodesist

LARGER in area than the continent of Europe, Canada is a country of vast extent, whose population, industry, and systems of surface transportation are concentrated in a relatively narrow strip of territory adjoining the International Boundary on the south. As a result, geodetic surveys in the last half-century have to a great extent been carried out in this southern area, which has offered the easiest local routes of transportation and permitted more or less easy access to the areas immediately to the north.

In order to understand the background of the recent electronic survey in the far north, it is advisable to review briefly the achievements in using the methods of classical geodesy in the southern and settled areas.

To provide a basis of control, it is necessary to determine the position in latitude and longitude and also the elevation above mean sea-level of many points across the country for use in mapping, engineering projects, studies of hydrology affecting the Great Lakes basin, boundary delimitations of provinces (notably the 60th parallel of latitude), etc. This control must be done with the highest precision, as it is intended not only to serve specific local needs but to contribute scientific data of acceptable standard for studies such as the determination of the size and shape of the earth.

I. Progress by Methods of Classical Geodesy

(a) *Triangulation* is one of the basic methods for position determination and is composed of first and second-order arcs which in general follow the routes of transportation. It provides numerous control points within a narrow belt and also the lengths between stations which serve as checks for local surveys. Minor triangulation may be extended laterally from the belt to increase the density of control for other purposes.

Triangulation consists of a chain of overlapping triangles in which the angles between the stations visible from an instrument station are measured with precise theodolites. To maintain direction and scale, each net of some 200 miles axial length is conditioned by one or more Laplace

azimuths (free of deflection error) and by a base line measured with invar tapes. For first order accuracy, triangles are made to close within one second of arc, and the discrepancy between the measured value of the base line and that obtained through the triangulation has to lie within specified limits.

The total axial length of all nets triangulated since the inception of the Geodetic Survey in 1905 is 14,200 miles.

At the present, no continuous arc extends from east to west in Canada, but work is now under way to effect this by closing a 400-mile gap north and west of Lake Superior.

The system is reduced on the 1927 North American Datum, which is international in character and is gradually being extended in use southward from Mexico to the South American continent.

(b) *Astronomy* is the second basic method of position, but from the viewpoint of surveys on the ground it has a serious fault. This arises because the perpendicular to the earth's surface does not in general coincide with the direction of gravity as indicated by a plumb line. Local surveys may be placed in position by one astronomic point, but if two points are used and the connecting azimuths and length are computed these will not agree with those determined by linear survey. The difference is relatively large. The difference between the geodetic and astronomic values is referred to as a deflection of the vertical, and is caused by the uneven distribution of mass. In Canada the average deflection of the vertical found by precise instruments and methods, in both meridian and prime vertical components, is of the order of 330 feet, with an observed maximum of 2053 feet in the meridian component (area, Gaspé Peninsula). We may then say that a distance found from astronomic values may be in error as much as 660 feet on the average.

To date 359 precise astronomical stations have been established by the Geodetic Survey. These include 92 Laplace azimuth stations, 306 deflection points (including most of the Laplace points) for investigations in isostasy, and 43 points as control for boundary demarcation such as the 60th parallel between the Prairie Provinces and the Northwest Territories.

There are about 1040 second-order astronomic points scattered quite generally over the northern mainland and the southern fringe of the Arctic Archipelago. These points have been determined for control of small-scale aerial mapping. The position determinations were made with a 5-inch theodolite using the equal altitude method which gives simultaneous determination of latitude and longitude.

In general, astronomically determined positions have been of great use in eliminating the bulk errors of the shore lines of the northern coast

and in the positions of islands on our early maps. Errors up to 30 miles have been detected, while revisions of three to six miles are quite common.

(c) *Base Lines* of precision have so far been measured with 50 metre invar tapes but in 1956 the Bergstrand geodimeter was employed concurrently on two base lines, and it is the intention to use this instrument to replace tape measurements.

The velocity of light has now been established very accurately, and by accepting this known velocity, the length between two visible points can be measured by determining the time that light takes to travel between the points.

The geodimeter makes use of a source of incandescent light which is modulated by a Kerr cell and crossed polaroids and then, through a suitable optical system, is made to travel to a distant reflector and back to the geodimeter.

The results of only two base lines (lengths 4.8 and 6.2 miles) have so far been reduced, and the agreement between the two methods is of the order of 1 in 300,000 (1 inch in five miles). This degree of accuracy has been obtained in many other countries.

The use of the geodimeter in base-line measurements for lengths up to 20 miles will result in greater economy not only in time but also in work, because it eliminates the requirement of a base extension system to the main lines of the triangulation scheme and the cutting of forest between the end points of the base for invar-tape measurements. The geodimeter can give an acceptable base-length determination in a few nights of observation, while up to six weeks are required in the invar-tape method.

(d) *Precise Levelling* is used to determine elevation above mean sea-level and was first undertaken by the Geodetic Survey in 1907, although the federal Department of Public Works had done a good deal of work before this date.

In the early days most of the levelling was over railway routes and recently it has been extended to highways of all classes. As new routes, both railway and highway, are built to open up hitherto inaccessible country, precise levels are carried forward as soon as possible.

At the end of 1955 the levelling covered work in all ten provinces and two territories and included connections to points in three states of the U.S.A. For adjustment purposes the level net is composed of 450 links joining 332 junction points.

The system comprises 53,468 miles of precise levelling with 15,728 bench marks.

It is easily realized that the extension of the precise level net to

northern areas can only be done in slow steps and the time element is dependent upon the general development of these areas. Supplementary elevation data are possible through radar altimetry, barometric and field levelling, none of which can maintain standards approaching those of precise levelling.

The Canadian levelling system is based on tidal stations which define mean sea-level, i.e. Halifax, Yarmouth, Father Point, Sydney and Churchill on the east; Vancouver and Prince Rupert on the west. The tidal stations are operated by the Hydrographic Survey. Mean sea-level is the natural plane of reference and is found from the average of observations on automatic registering gauges taken over a period of years. The daily rise and fall of tide is evident, but the mean position from day to day is not constant, and observations must cover a long period to provide the necessary datum of zero elevation. The elevation obtained at Vancouver by levelling from Halifax across the continent, differed by only 0.6 foot from the tidal value, and this was considered to arise solely in the levelling operations and not to be due to any difference in sea-level on the two coasts.

II. Shoran Trilateration

If we examine an index map on which the broad outlines of the classical work is pictured, it is seen that much has been accomplished but that a vastly greater amount remains to be done to establish control in the northland. If we bear in mind that the work in the southern areas represents 50 years of effort and if we use this rate of progress as a measure of future accomplishment in the northern areas, it is even more easily seen that more or less general control by methods of classical geodesy cannot be established in perhaps the next 100 years.

In contrast, air photography of the area has advanced so that at the end of 1954 photo coverage existed for the entire country, of which about 70 per cent. is vertical, 25 per cent. is trimetrogon and the rest is a remnant of the older oblique photography. Under favourable weather conditions it will be possible to have the whole of Canada, exclusive of the Arctic islands, covered by vertical photography by the end of 1957. We shall then have for most of the country all the characteristics of terrain in minutest detail. The transfer of this detail to maps can only be done with accuracy if control sufficient to the scales of the required maps is available.

The airplane has made most of the north country accessible, and this has intensified the recent search for mineral wealth with results of great

economic importance. World-wide conditions have also focussed attention upon defence matters. The requirements for economic development and defence have emphasized the immediate need for a vast improvement in the scale, accuracy and detail of newer maps to replace those hitherto available. To satisfy this demand a more rapid method of control had to be employed, and the answer was electronic measurement of rather long lines by Shoran to form a trilateration net. Because of the vast extent it had to cover, this trilateration, to be satisfactory, had to give accuracy in position better than that obtainable by astronomic means.

Trilateration is a system of overlapping triangles in which the lengths at the sides are measured electronically in contrast with triangulation where the angles are measured. Since the lines between trilateration stations average 230 miles with a maximum, so far measured, of 369 miles, we prefer to change the story book version of seven-league boots to *seventy-league* boots, in our efforts to cover a large area in a short time.

(a) *Historical.* The term Shoran is a contraction of the phrase *Short Range Aid to Navigation*, and although its tactical employment was greatly delayed, Shoran was one of the first radar systems to be developed during World War II. The initial Shoran idea was conceived in 1938 and further development by Stuart W. Seely of the Radio Corporation of America. The first development model was delivered in February 1942, under contract with the U.S. Army Air Force's Aircraft Radio Laboratory, and tested for use on navigating the bomb run and indicating release points for bombardment aircraft. The early flight tests were highly satisfactory, but production of equipment was delayed; and only in the latter part of 1944 was Shoran put to tactical use with great effect in bombing vital pin-point targets in northern Italy. In this respect its principal function was the accurate positioning of an aircraft with respect to two remote but known positions on the earth's surface.

As applied to geodesy, the system affords an electronic method of measuring long distances between remote points on the earth's surface. In its application to photographic survey, Shoran is capable of supplying information through which, in conjunction with a Straight Line Indicator, an aircraft can be kept in straight-line flight. At the same time positioning of each vertical photograph can be obtained with respect to two known positions. As geodetic fixation necessitates very high accuracies, the earlier Shoran instrumentation has been modified to this purpose, new equipment has been developed, and specialized techniques evolved for its application in higher surveying.

The application, in Canada, of Shoran electronic length measurement to surveying and mapping may be regarded as having been initiated in 1947, when experimental work by federal government bureaus was conducted in the vicinity of Ottawa over several long lines between stations of the first-order triangulation. During the succeeding two winters, this work was continued with results which indicated Shoran would be suitable for establishing position, in Canada's vast northland, quickly and with greater accuracy than by the former method of astronomic positions of either exploratory or precise nature.

The first trilateration net undertaken was an arc of 1100 miles in axial length between geodetic bases. This proved that, with careful supervision of all details, results with accuracy superior to astronomic positioning could be secured. This net was completed in the summer seasons of 1949 and 1950.

The trilateration has been advanced steadily in the succeeding summers, exclusive of 1954, and now has reached latitude 85°. Attachment to the existing triangulation along the western, southern, and eastern periphery of 4,500 miles has been made at 18 triangulation stations.

(b) The *organization* required for the Shoran programme is extensive and involves personnel of the Royal Canadian Air Force, National Research Council, Meteorological Service, and the Geodetic Survey. The R.C.A.F. has provided all aircraft used in reconnaissance, station installation and line-crossing. Amphibious Canso aircraft supported by float-equipped Norseman, or more recently Otter, aircraft have been used for station preparation and installation, and Lancaster bombers have been adapted for line-crossings. A communications system is also a necessity during operation, for local meteorological data and for safety. For this, and the above related duties, some 250 service personnel are assigned for a season's operation. The National Research Council has aided in the solution of electronic problems and in calibration, and by the design and construction of recorders and navigational aids. The Meteorological Service has contributed the observational data from weather stations surrounding the areas involved, and seconded a meteorologist to assist in the computations. To the Geodetic Survey has been assigned the reduction and assessment of the accuracy of the results, together with general supervision during the course of operations to maintain a uniform standard of procedure.

When it is realized that the field season for float aircraft is of about three months' duration in lower latitudes and less in higher latitudes, one gains an appreciation of the necessity for personnel to be highly trained in order to take full advantage of the short period of operation. The

transportation of equipment, personnel and provisions some 2,500 miles by air, shelter for manpower, maintenance and operation of antenna sites, servicing of both line-crossing and supporting aircraft, combine to make the operation a challenge to all concerned. Effective results in these matters have been obtained through close team work, which in turn has greatly speeded line-crossing operations.

(c) The *distances* from an airplane to two Shoran stations involves the measurement of the time interval required for pulses to travel the direct and return paths. The airplane is made to traverse a figure-eight pattern near the midpoint of the line (see figure 1) with each crossing at constant speed, direction and height. The pulses sent out are on two frequencies and each station responds on a common third frequency. On an oscilloscope the leading edges of the return pulses are matched with marker pulses, and by a complex associated gear mechanism the travel time interval is converted to miles and indicated on dials.

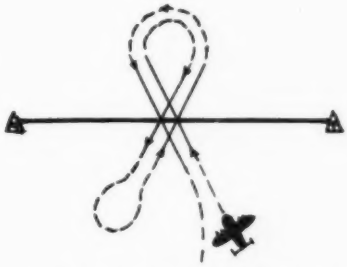

FIG. 1—Four line crossings by plane in form of figure eight constitute one-fourth of programme of Shoran readings on each line.

In Canadian Shoran two figure-eights giving eight measurements are made one day and duplicated on another day. Due to varying conditions the agreement of the results of the two days may not meet the required specifications, and in this case reflights are requested. It is stressed that agreement of values in one day does not necessarily mean accuracy.

Each line-crossing gives a series of microfilm data which when plotted will determine the minimum sum of the lengths from the plane to the stations. Each sum is subject to corrections of instrument calibrations, meteorological factors, and geometrical reduction to sea-level.

As an example of the consistency of measurement, previous to corrections, we have tabulated (Table I), the results of two days for the line, Eskimo–Coats.

TABLE 1

DISTANCE MEASUREMENTS ESKIMO–COATS
Aircraft 112 Flight Height 20,000′
Indicator 1405 Recorder 1

August 2, 1952		August 3, 1952	
348.5903 mi.	348.5928 mi.	348.5886 mi.	348.5898 mi.
.5909	.5886	.5899	.5931
.5838	.5874	.5870	.5889
.5833	.5890	.5881	.5869
.5871	.5895	.5884	.5897
348.5883		348.5890	

Above means reduced to sea-level, 348.0122 and 348.0121 miles.

Some idea of the internal accuracy obtained may be found from analysis of the 1949–53 operations. From 325 "lines" it was found that measures on two separate days agreed with each other within 21 feet 50% of the time and within 35 feet 75% of the time.

Further analysis included the 1955 work so that 384 measured lines were available for study. The average length of line is 230 miles, average correction resulting from a general adjustment is 21.4 feet so that on the average distances may be said to be measured to an accuracy of 1 in 56,000 or about one inch per mile.

(d) The *trilateration net* inclusive of the 1956 work is shown in figure 2. Inclusive of 1956, 106 stations were established and 441 lines measured. The net is attached to 18 geodetic triangulation stations which furnish position and scale. The geometric pattern is that of quadrilaterals and pentagons with overlapping lines.

In our case it was desired to secure overall coverage, but general strength dictated that there should also be included some chains of denser pattern. We think the treatment of the area as a whole, rather than by chains separated by large areas within which subsequent work could be done, has contributed greatly to the accuracy in placement.

During the course of operations it has repeatedly been brought to our attention that Shoran is a complicated business, prone to errors from a great many sources such as the heights of aircraft and station, assessment of meteorological factors, operation and maintenance of electronic equipment, supervision of manpower, etc. These and many other factors cannot always be maintained at the highest level and inaccuracies are contributed to the final result. Mere agreement of line-crossing values does not in itself assure accuracy and yet it is one of the required factors when things are being done properly both by the personnel and equipment. We have been chided by some very high authorities as being too modest

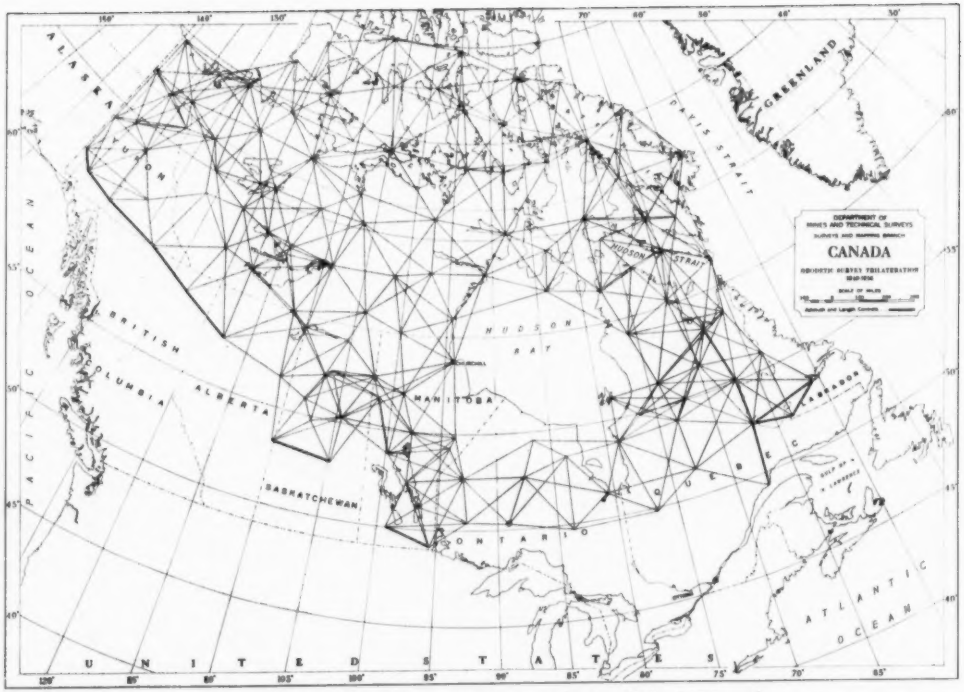

FIG. 2—The Canadian triangulation net inclusive of the 1956 work.

in our assessment of the accuracy attained, but we prefer to be on the safe side and let future connections by triangulation give us the answer as to what has happened and particularly in the geodetic sense where tension, compression and distortion have been generated.

The Shoran fixation is admittedly inferior to first-order triangulation but definitely superior to astro-fixation. Mapping operations are currently using the Shoran fixation, extending the control within the basic scheme, and flying Shoran-controlled photography.

(e) *Summary.* With the 1957 operation completed, there are 501 measured lines and 119 Shoran stations widespread over some two and one-half million square miles (area Canada, 3,845,774). For the best placement the entire work should be adjusted as a unit, but as this involves too much labour for the slight gain in accuracy, the 1956 and 1957 portions will be adjusted as a unit and based upon the just completed adjustment of work south of the Arctic coast.

We may summarize some of the features dealt with as follows:

The Shoran trilateration is indicated as having an average line measurement accuracy of 1 in 56,000 (1.2 inches in 1 mile) after the calibration error is applied.

The average correction for a line is 21.4 feet.

Three stations since placed in position by triangulation indicate error in placement within circles of radii 11, 18 and 30 feet.

If systematic error were eliminated, northern stations would not be in error by more than an 80′ radius of absolute position.

Due to systematic error not being eliminated in full degree, we assess the error in position in the extreme northern limit of the net to be a possible 150′ with the probability of an occasional 300′ for external, remote stations.

The inter-relation of stations in length in local areas is maintained to a high degree, of order 1 in 56,000, irrespective of errors in position.

The accuracy is assessed as of second order and amply sufficient for the purpose for which it was designed. It fulfills the requirements for Shoran-controlled photography in the production of large-scale maps.

The trilateration accuracy placement will be improved with time, as Shoran stations are incorporated in the triangulation network.

This in turn will improve its value from the geodetic viewpoint quite apart from its mapping aspect.

The trilateration considered in the adjustment was completed in 6 seasons of operation.

METEOR NEWS

By Peter M. Millman, *National Research Council, Ottawa*

Photographic Meteor Spectra (Appendix 5)

As in previous years I am listing here all the photographic meteor spectra of which I have knowledge, and which have not been included in previous lists (see the Journal, Vol. 46, p. 121, 1952; vol. 47, p. 217, 1953; vol. 48, p. 225, 1954; vol. 49, p. 169, 1955; and vol. 50, p. 181, 1956). This appendix includes spectra up to the end of 1956. The serial numbers given in column one are intended for use in making references to the spectrum.

List of Photographic Meteor Spectra (Appendix 5)

No.	Date			U.T.			Shower	Location (observatory)	Ref.
	y	m	d	h	m	s			
195	1955	8	12	7	53	*	P	Blairsden, Calif. (U.S.C.)	
196	1956	8	10	5	34	43	P	Meanook-Newbrook, Alta. (D.O.)	
197		8	11	8	3	*		Blairsden, Calif. (U.S.C.)	
198		8	11	9	6	*	P	" " "	
199		8	11	11	11	*	P	" " "	
200		8	12	1	17	*	P	Barnes, S.W. 13 (W.B. Ridley)	
201		8	12	5	28	25	P	Regina, Sask. (R.A.S.)	34
202		8	13	9	15	*	P	Meanook, Alta. (D.O.)	
203		8	13	9	40	*	P	" " "	
204		8	13	10	23	*		" " "	
205		8	14	3	40	*	P	Barnes, S.W. 13 (W.B. Ridley)	
206		8	14	7	16	11		Meanook-Newbrook, Alta. (D.O.)	
207		8	15	7	49	52	P	Meanook, Alta. (D.O.)	
208		9	30	00	07			Barnes, S. W. 13 (W.B. Ridley)	
209		10	15	12	17	11		Meanook, Alta. (D.O.)	
210		11	1	12	48	*		Meanook-Newbrook, Alta. (D.O.)	
211		11	27	6	03	*		Newbrook, Alta. (D.O.)	
212		12	12	9	08	*		Meanook, Alta. (D.O.)	
213		12	12	10	23	03	G	" " "	
214		12	13	04	11		G	Barnes, S.W. 13 (W.B. Ridley)	

Abbreviations—

G Geminid
P Perseid
*Indicates middle of exposure.

D.O. Dominion Observatory
R.A.S. Regina Astronomical Society
U.S.C. University of Southern California.

Routine meteor photography was carried out during 1956 at the Meanook and Newbrook Meteor Observatories in Alberta. This work is under the direction of Dr. Ian Halliday at the Dominion Observatory, Ottawa, and the exposures were made by A. A. Griffin, J. M. Grant and D. Corness as well as by Dr. Halliday himself.

Professor J. A. Russell continued his summer program of meteor photography in California and met with considerable success, securing three spectra. Mr. W. B. Ridley again obtained spectra near London, in England.

The Regina Astronomical Society photographed their second spectrum in August of 1956 as has already been reported in the JOURNAL.

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33. Cook, A. F. and Millman, P. M., *Ap. J.*, vol. 124, p. 476, 1956 (Spectrum 110).
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VARIABLE STAR NOTES

American Association of Variable Star Observers

By Margaret W. Mayall, *Director*

To set up a clear cut system of classification for any group of objects in nature is always a difficult problem. Borderline cases seem to occur more often than definite classes. Variable stars are no exception.

In addition to the well-known types of peculiar and irregular variables, such as U Geminorum, RV Tauri, Orion, R Coronae Borealis, novae, and so forth, there is a large group of long periods which at times look quite similar to typical long-period variables such as Mira. At other times these variables may suddenly increase or decrease their total ranges of brightness or even may remain constant for months or years.

A good example of this peculiar variation is 082405 RT Hydrae. Its light curve was given recently in these Notes. (See this Journal, vol. 51, no. 5, p. 308.) An even more interesting light curve is shown in figure 1, of the variable star 115158 Z Ursae Majoris. The plot is a 10-day mean curve of visual observations made by members of the A.A.V.S.O. between 1928 and 1957. The spectrum of Z UMa is M6e, and it is listed in the catalogues as having a semi-regular period of 198 days. The curve shows it nearly constant for several hundred days around J.D. 2426500 (1930–1932), and again for nearly 1500 days between 1945 and 1948. For several years following its long inactivity, the star appeared quite regular with a range of 2 magnitudes, then it developed a marked secondary maximum between the years 1953 and 1955. The most recent observations seem to indicate a return to regular variation.

Another variable with peculiar and interesting irregularities, 015254 U Persei, is shown in figure 2. The chief peculiarity in the light curve of U Persei is the variation in depth of minima. Most long-period variables have a considerable variation in the height of maxima: for example, Mira may be as bright as 2nd magnitude at maximum, or it may only reach 5th magnitude. U Persei is about 8th magnitude at maximum, but minimum may be anywhere from 9½ to 12.

U Persei has a spectrum of M6e, and its period is published as 319 days. The visual light curve usually shows a broad maximum and a sharp and well-defined minimum. At times a secondary hump appears near the maximum, but there is no indication of the half period of 167 days suspected from some photographic observations.

The following table is a continuation of the dates of maxima and minima of U Persei published in Leon Campbell's "Studies of Long Period Variables." (A.A.V.S.O., Cambridge, Mass., 1955.) The first column is the number of the maximum, as numbered consecutively from the first one observed in 1890, J.D. 2411639. Column 2 is the Julian Day of maximum; column 3 the maximum magnitude; column 4 the number of days to the next maximum; and columns 5, 6, and 7 give the same data for minima. The mean value of the period for the 75 observed epochs is 322 days.

MAXIMA AND MINIMA OF U PERSEI, 1948–1956

	Maxima			Minima		
No.	J.D.	Mag.	Diff.	J.D.	Mag.	Diff.
66	2432879	8.0	319	2432720	11.5	319
67	3198	8.0	334	3039	11.0	323
68	3532	7.9	329	3362	11.2	341
69	3861	8.1	321	3703	11.4	325
70	4182	8.0	317	4028	11.9	327
71	4499	...	320	4355	11.2	321
72	4819	8.0	324	4676	11.1	321
73	5143	8.2	328	4997	11.4	321
74	5471	7.9	319	5318	11.6	325
75	5790	8.1	...	5643	...	319

A survey was made of all the long-period variables on the A.A.V.S.O. observing programme which had fairly continuous light curves plotted for 20 years or more. Figure 3 is a plot of the mean range in magnitude against period for these stars. When the light curve exhibited marked peculiarities such as shown in the variables mentioned above, it was plotted as an open circle instead of a solid dot. This plot clearly confirms the idea that a red variable star with a period over 100 days and a small magnitude range is very likely to have an interesting and changing light curve. All of the stars with ranges of 4 magnitudes or less should be watched for these peculiarities.

A.A.V.S.O. Nova Search Report (from George Diedrich, Chairman). The 225 area-nights of observation by 15 observers were made as follows. The name is followed by the observations made in June 1957 and then July 1957: CASIMIR BLASCZYK–9, 0; JAMES BRECKINRIDGE–6, 6; DELORNE DIEDRICH–3, 4; GEORGE DIEDRICH–8, 13; PAUL DIEDRICH–6, 4; RICHARD GEMBERLING–9, 10; ROBERT JACOBSON–22, 4; EDWARD MAJDEN–2, 0; BEAUFORT RAGLAND–9, 8; JANE SHELBY–8, 14; ELIZABETH SOCHA–4, 22; SAMUEL TERRY–2, 10; JAMES WESLING–5, 4. The following, previously unreported, observations were made by the persons indicated with observations listed after names in the order of November 1956; March 1957; and May 1957: EARL MILTON–0, 13, 0; DONALD ROSENFIELD–1, 0, 0; JANE SHELBY–0, 2, 3; JAMES WESLING–0, 14, 0.

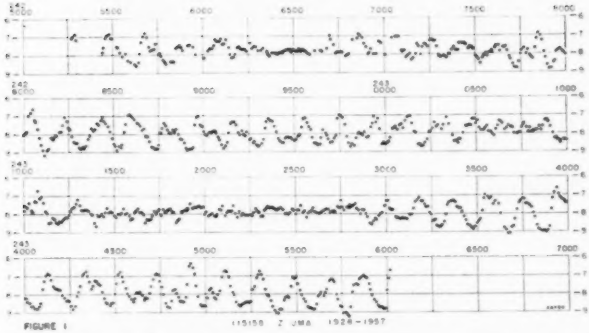

FIGURE 1

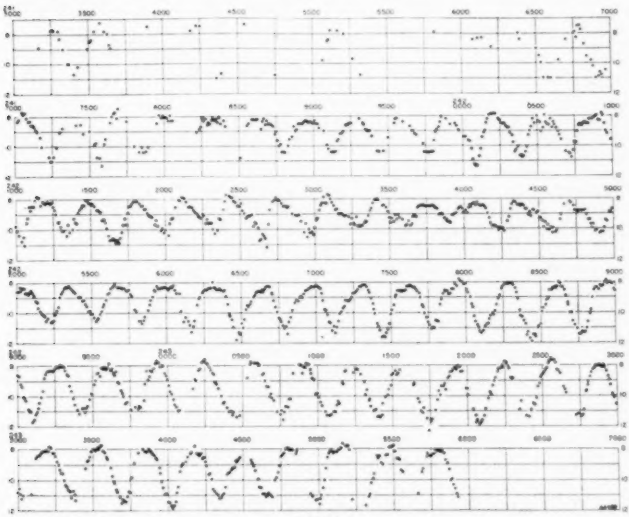

FIGURE 2

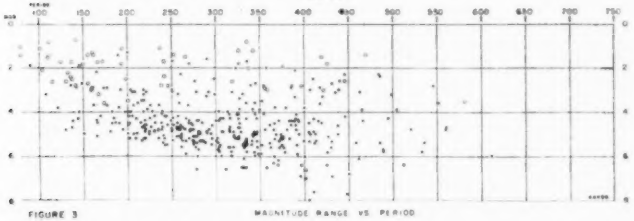

FIGURE 3

Observations received during July and August 1957: In July, 63 observers contributed 3860 observations, and in August, 54 sent 3854, a total of 7714 observations for the two months.

Observer	July		August		Observer	July		August	
	Var.	Ests.	Var.	Ests.		Var.	Ests.	Var.	Ests.
Adams, R. M.	62	140	66	174	McGovern, R.	..	..	6	10
Anderson, C. E.	143	205	179	307	McPherson, C. A.	20	20	31	31
Beidler, H. B.	22	42	25	40	Miller, J. S.	..	..	2	2
Bicknell, R. H.	21	163	14	120	Montague, A. C.	41	83	44	62
Bieda, S. W.	2	11	..	..	Morgan, F. P.	7	7	4	4
Breckinridge, J.	12	28	1	3	Oravec, E. G.	208	427	204	376
Buckstaff, R. N.	11	29	..	..	Overbeek, M. D.	66	170	..	..
Byrd, W.	..	..	8	32	Parker, P. O.	51	51	69	75
Carlisle, J. H.	..	..	2	3	Paulton, E. M.	8	8	4	4
Carpenter, C. B.	17	17	45	45	Pearcy, R. E.	3	3	3	3
Clarke, J. B.	1	1	..	..	Pearlmutter, A. E.	..	..	36	91
Cleary, C.	7	9	..	..	Peltier, L. C.	16	70	23	114
Cragg, T. A.	144	149	197	202	Pilcher, E.	3	3	3	3
Cunningham, R.	2	15	..	..	Price, F.	27	57	30	71
Darsenius, G. O.	1	1	5	9	Renner, C. J.	188	252	..	..
Debono, I. P.	2	7	4	18	Reynolds, F. H.	..	..	4	27
Diedrich, DeL.	2	2	2	7	Rizzo, P. V.	18	38	19	33
Diedrich, G.	3	7	7	21	Robinson, L. J.	37	95	55	184
Erpenstein, O. M.	..	..	6	10	Rosebrugh, D. W.	9	88	11	104
Fernald, C. F.	156	347	174	364	Schultz, G. W.	4	4	..	..
Ford, C. B.	127	134	171	183	Segers, C. L.	26	77	32	84
Gemberling, R. H.	6	24	7	27	Seldon, P.	11	21	29	151
Gernant, P.	5	5	..	..	Sloan, M. A.	1	2	..	..
Goldenblatt, P. P.	16	22	..	..	Socha, E. M.	1	1	1	2
Goodsell, J. G.	1	1	2	2	Solomon, L.	8	10	16	18
Hanawalt, R. A.	2	3	4	14	Styczynski, J.	2	3	..	..
Hartmann, F.	122	132	127	141	Taboada, D.	85	98	..	..
Hein, G. J.	9	14	23	32	Taulman, D. C.	12	14	..	..
Herbig, G. H.	42	45	..	..	Thurn, V. W.	12	18	..	..
Howarth, M.	14	14	12	12	Tsai, C. H.	..	..	29	60
Hutchings, N	2	13	..	..	Turtle, J. P.	4	4	9	16
Kelly, F. J.	10	10	11	14	Usakowski, C.	1	2	3	3
de Kock, R. P.	132	507	124	419	Walko, K.	3	3	6	8
Kofoed, R.	5	9	12	13	Wayland, K. A.	2	4	..	..
Lacchini, G. B.	44	93	12	19	Weitzenhoffer, K.	3	3	9	23
Lowder, W. M.	17	25	23	32	Welker, F.	..	..	20	32

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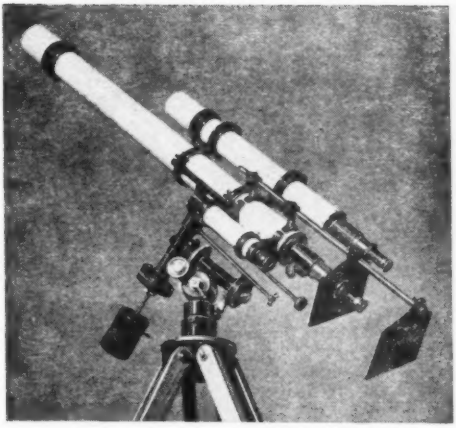

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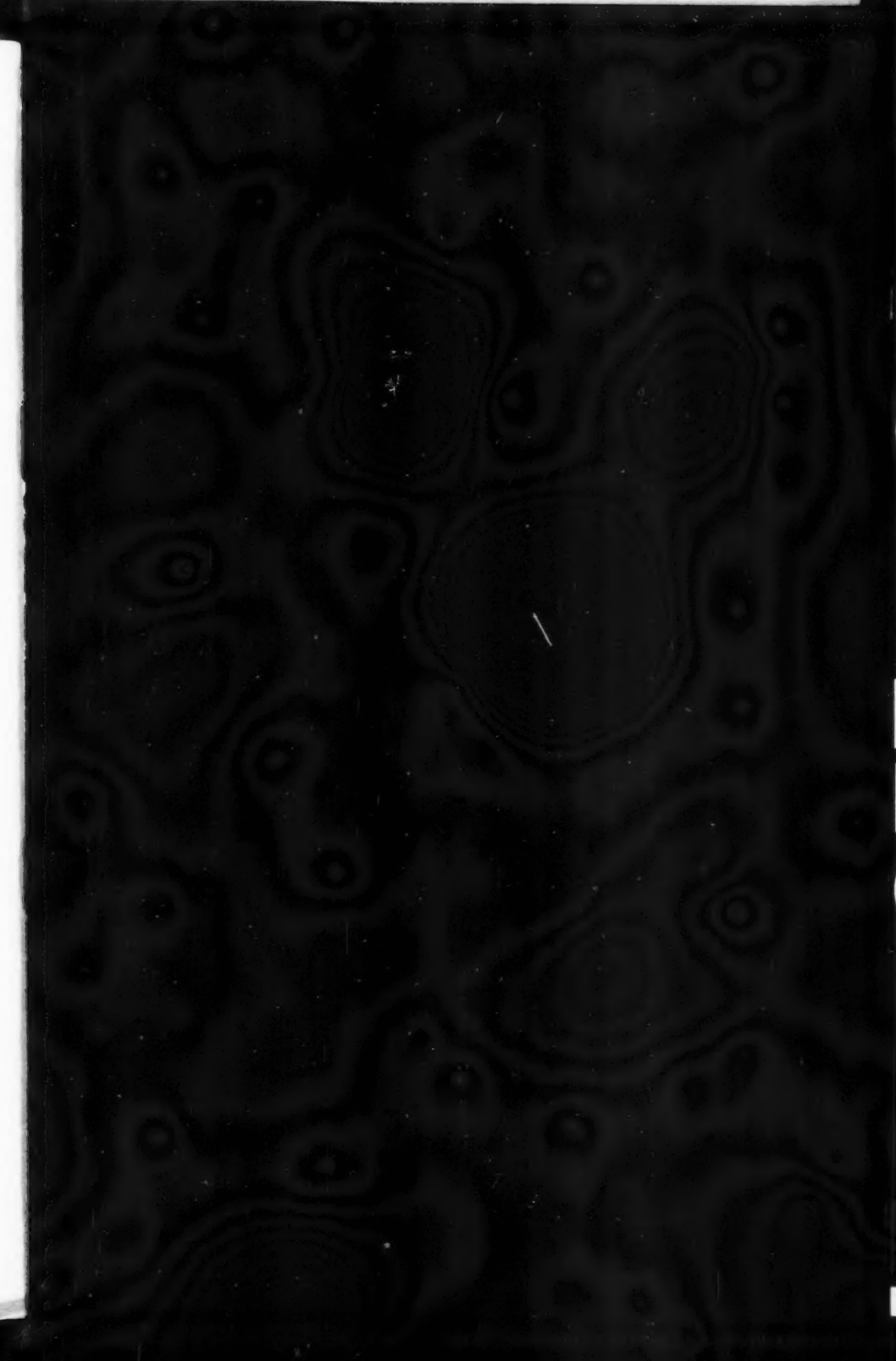
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